

**SUSTAINABLE WASTEWATER SYSTEMS FOR TEXAS COLONIAS:
ALTERNATIVES ANALYSIS FOR EL PASO COUNTY**

An Applied Research Paper
Presented to
The Academic Faculty

by

Marcela Nicole Moreno

In Partial Fulfillment
of the Requirements for the Degree
Master of City and Regional Planning in the
School of City and Regional Planning

Georgia Institute of Technology
August 2017

COPYRIGHT 2016 BY MARCELA MORENO

ACKNOWLEDGEMENTS

I would like to thank my father for his endless guidance and support in writing this option paper, and my mother for her help with translations. Also, my advisor Dr. Bruce Stiftel for his valuable insight and feedback on my research, and planning career. A major thanks to all the interview participants whose insight into colonias has given me insight on an issue that I have grown more and more passionate about.

This paper would not be a reality if I did not have the understanding and support from my friends, all of whom would understand my long absences and incomplete thoughts throughout the writing process. Last but not least, I would like to thank my new friends and colleagues from the Water Initiative for the Future conference whose feedback and support during the last stretch of my research was very much needed and appreciated.

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	ii
LIST OF TABLES	v
LIST OF FIGURES	vi
SUMMARY	vii
<u>CHAPTER</u>	
1 INTRODUCTION	1
History of Colonias	2
2 LITERATURE REVIEW	5
Current Colonia Demographics	5
Recent Efforts in Colonias	10
Wastewater Services and Colonias	11
Other Critical Issues	15
Informal Wastewater System Case Studies	16
International and Domestic Case Studies	17
Conclusions from Literature	20
3 RESEARCH PURPOSE AND DESIGN	21
Research Questions	21
Methodology	22
4 EXISTING INFRASTRUCTURE AND CONDITIONS IN COLONIAS	25
Physical Environment of El Paso County	25

Capital and Funding Sources	27
Current Wastewater Disposal Systems	27
5 TECHNOLOGIES FOR CONSIDERATION	38
Stabilization Ponds	38
Dry Composting Toilets	44
Constructed Wetlands	48
Package Plants	54
6 RECOMMENDATIONS & CONCLUSION	58
Conclusion	58
Recommendations	58
Further Research	59
APPENDIX A: Colonias Interview Guide	61
APPENDIX B: List of Interviewees and Affiliation	62
REFERENCES	63

LIST OF TABLES

	Page
Table 1: Texas Colonia Classification System	7
Table 2: Rural Community Assistance Partnership Priority Score Definitions	8
Table 3: Demographics of Colonias v. State of Texas	9
Table 4: Pros and Cons of Cesspools	31
Table 5: Pros and Cons of Septic Tanks	34
Table 6: Pros and Cons of Stabilization Ponds	39
Table 7: Treatment Efficiency of Stabilization Ponds	43
Table 8: Pros and Cons of Dry Composting Toilets	45
Table 9: Pros and Cons of Constructed Wetlands	50
Table 10: Wastewater Treatment Efficiency for Constructed Wetlands	53
Table 11: Pros and Cons of Package Plants	55

LIST OF FIGURES

	Page
Figure 1: Framework of the Components of Drinking Water Infrastructure	12
Figure 2: Soil Map of El Paso County	26
Figure 3: Map of Colonias in El Paso County	29
Figure 4: Diagram of Cesspool	32
Figure 5: Diagram of a Septic Tank	35
Figure 6: Diagram of an Anaerobic Stabilization Pond	40
Figure 7: Diagram of a Dry Composting Toilet	46
Figure 8: Diagram of Constructed Wetlands	51

SUMMARY

Government institutions and non-governmental organizations have made great strides in improving infrastructure and services to colonias (Spanish for communities or neighborhoods) in Texas. Colonias are a response to the lack of affordable housing along the border but a high demand for cheap labor in agriculture, manufacturing and service industries. These communities lack basic infrastructure like accessible roads, electricity, and wastewater and water services. Despite progress made from local, state and federal initiatives to bring colonias to these municipal services, according to the Federal Reserve Bank of Dallas, there are still 337 communities that fall under the most critical need area (red). The majority located in El Paso County, located on the western border of Texas and Mexico. Many of these colonias that continue to lack access to wastewater are located in remote areas and may rely on either failing septic systems, cesspools or outhouses that may pose a risk to private wells. Adequate wastewater disposal systems are critical to preventing contaminated water from harming colonias residents and their surrounding communities, and the ecosystem of the Rio Grande Valley. Through analysis of the current state of these colonias, research on different wastewater solutions being implemented around the world, and interviews with colonia experts, a dry composting toilet is proposed for policy makers, community activists, and wastewater utilities to consider for implementation.

CHAPTER 1

INTRODUCTION

In 2010, the United Nations established the human right to clean water and sanitation in response to the lack of access to wastewater and clean water due to rapid urbanization across the globe. The Millennium Development Goals established in 2000 aimed at halving the amount of people without sustainable access to clean drinking water and basic sanitation. In United States it is often cited that 100 percent of US citizens have access to water and sanitation services; however, this is not the case (Rural Community Assistance Partnership, 2004). Without adequate service, improper wastewater disposal poses a health risk to surrounding communities and the environment.

Despite the standard of living enjoyed by the majority in the United States there are still approximately 1.7 million people living without service to basic plumbing systems (Rural Community Assistance Partnership, 2004). Populations living in these conditions are already marginalized by their socioeconomic status as impoverished (more often than not) minorities. These populations are found throughout the United States, primarily in rural areas. While there has been progress since the 1950s (27% of households lacking complete plumbing facilities), there are still .64% of Americans that do not (Rural Community Assistance Partnership, 2004). In Texas, there are pockets of people that have lacked wastewater service in informal communities whose conditions are comparable to developing countries. While there has been legislation and advocacy efforts to bring these communities to a higher standard, there are still approximately 130 colonias (with a population of 49,101) in the United States lacking wastewater service or

drinking water AND (or may) present a health hazard (Rural Community Assistance Partnership, 2015). According to the Rural Community Assistance Partnership, these colonias are designated as “Priority One”. Following a similar pattern to the greater United States, there has been progress in colonia development, but there are still colonias that lack access to clean water and basic sanitation systems.

This paper will explore the wastewater issues faced by colonias in the El Paso County, Texas. The first chapter of this paper introduces the reader to colonias, and a history of how they came to exist. The second chapter reviews of literature related to colonias and different wastewater technologies implemented in similar conditions to colonias. The third chapter discusses the research questions and the methodology and criteria used to produce recommendations. Specifically, it discusses the interviews with experts in colonia wastewater issues create an overview of the current infrastructure in El Paso County to explore potential wastewater technologies for the remaining Priority One colonias, and explore the current regulatory and political framework colonias development works within. These interviews inform the fourth chapter on the existing physical and regulatory infrastructure colonias exist within. The fifth chapter will discuss the various technologies under consideration for colonias—including constructed wetlands, composting toilets, package plants, and stabilization ponds. The conclusion of this paper is a set of recommendations for non-profits, policy makers, utilities and others involved in wastewater planning for colonias.

History of Colonias

Colonias, Spanish for “neighborhood or community”, have existed in the United States since the 1950s. They are informal settlements built along the border in response to a lack of affordable housing in the region. These communities often lack basic

infrastructure like electricity, paved roads, potable water, wastewater and solid waste disposal services. The advent of colonias started with landowners subdividing their plots into smaller parcels to sell to migrant workers with little to no means with the promise of access to infrastructure in the future. The land itself was “agriculturally worthless because they were located on floodplains or in dismal rural areas” (Lewis, 2015). In addition, the migrants did not have rights to the property since they “were unable to obtain the title to the property until the final payment was due” (Lewis, 2015). This left the community population without a legal position to demand utilities for their property, and with little to no value for ‘their’ property.

Mounting pressure from the public, spurred from articles like *The New York Times*’ “Along U.S. Border, A Third World is Born” by Peter Applebome, contributed to bodies of power establishing policies to help these communities. The United States House of Representatives’ Committee on Public Works and Transportation met on March 11-12th, 1988 to hear testimonies from colonias residents, community organizers, attorneys and others involved in community support. Subsequently, in 1989, the Texas Legislature “passed Senate Bill 2...to restrict futile development of colonias in Texas...[it] established the Economically Distressed Area Program (EDAP), which is administered by the Texas Water Development Board (TWDB)” (Parcher et al., 2007). EDAP’s focus was on border countries, but expanded to the entire state in 2005. Through the Texas Water Development Board, the Economically Distressed Area Program “provides financial assistance in the form of a grant, or a combination grant/loan to disadvantaged political subdivisions...EDAP projects can include: wastewater treatment plants, water towers, water storage tanks, sewers, pipelines...” (Lewis, 2015). This bill

also established the Model Subdivision Rules to ensure proper infrastructure in new colonia developments. The major criticism with this policy is that “it aids new development, [but] also prevents improvement and investments in many of the existing developments” (Lewis, 2015). No new regulation or updates on colonias have come from the Texas Legislature since 2005. The last piece of legislation, Senate Bill 827 resulted in the Colonia Health, Infrastructure and Platting Status tool Geographic Information System (GIS) database.

The first federal response to colonias was the Cranston-Gonzalez National Affordable Housing Act, which attempted to create a definite definition for colonias through the Department of Housing and Urban Development (HUD). The definition required that colonias meet the following criteria: it is situated in a border state, within 150 miles of the border but not within a metropolitan area with a population exceeding one million, designated as a colonia by the state it is in, determined to be a colonia due to the lack of infrastructure, and to be recognized prior to the Cranston-Gonzalez Act (Rivera, 2004). These pieces of legislation established the basic framework in which colonia development has worked in for over two decades.

CHAPTER 2

LITERATURE REVIEW

Current Colonia Demographics

Today, there are 2,177 colonias found in Arizona, New Mexico, California and Texas with a population of at least 829,910 people (Rural Community Assistance Partnership, 2015). Due to the majority of the border being located in Texas and its high labor demand, over half of colonias are in the state (1,884), with a population of 358,024 people (Rural Community Assistance Partnership, 2015). Hispanic Americans are the majority population in colonias.

Colonias fall under a multitude of jurisdictions, but the governmental body that provides state funding and legislation is the Texas State Legislature. There has been no new state regulation related to colonias since 2005. Another governmental organization that is a major part of colonia development is the Texas Water Development Board (TWDB), who is delegated the function to disburse state funds to communities and non-profits. Some federal organizations that have committed resources to colonias include the United States Department of Agriculture—Rural Development (USDA- RD), Department of Housing and Urban Development (HUD) and the Environmental Protection Agency (EPA).

In reviewing the current literature of colonias, there are two classification systems. The Texas Legislature developed system, and the other is a product of a Rural Community Assistance Partnership (RCAP) project funded by the Environmental Protection Agency and United States Department of Agriculture Rural Development

branch. Senate Bill 827 established the Texas State Legislature’s measurement system during the 79th Texas Legislature to track colonia development progress, and is presented in Table 1. The Rural Community Assistance Partnership developed the most recent framework for colonia classification in 2015. As opposed to using the Texas Legislature’s classification system, they determine priority in five numerical categories as illustrated in Table 2. Both classifications use indicators in infrastructure to categorize colonias, but the Rural Community Assistance Partnership’s focuses entirely on water/wastewater-related infrastructure. The reports show that El Paso County has the most colonias that fall under “Priority One”, whereas Hidalgo County has the most that are considered “red”. Both “Priority One” and “red” are considered highest priority under both classification systems.

In addition, The Federal Reserve Bank of Dallas recently released a report on colonia demographics and infrastructure data. Table 3 gives an overview of colonia demographics from 2015.

Table 1. Texas Colonia Classification System (Federal Reserve Bank of Dallas, 2015)

	Green	Yellow	Red	Unknown
Drinkable Water	✓	✓	X	-
Wastewater Disposal	✓	✓	X	-
Legal Plats	✓	✓	X	-
Paved Roads	✓	X	-	-
Adequate Drainage	✓	X	-	-
Solid Waste Disposal	✓	X	-	-

Table 2. Rural Community Assistance Partnership Priority Score Definitions (Rural Community Assistance Partnership, 2015)

Priority 1	Communities NOT served by a public water and/or wastewater facility AND a health hazard is (or may) be present
	<p>Colonia residents are NOT served by a public water system-- no health hazard indicated</p> <p>OR</p> <p>Colonia residents are NOT served by a publicly owned wastewater disposal system, and existing onsite wastewater treatment system is not adequate-- no health hazard indicated.</p> <p>OR</p>
Priority 2	Colonia residents ARE served by publicly owned water and wastewater facilities but one or both are in serious violation of regulations
	<p>Some residents are NOT served by a publicly owned water system</p> <p>AND/OR</p> <p>Some residents do NOT have access to wastewater service</p> <p>AND</p>
Priority 3	Plans are in development and proceeding for financing new water or wastewater services to all areas affect or are currently under construction
	<p>Residents ARE served by public water facilities</p> <p>AND</p> <p>Residents are NOT served by public wastewater service, BUT Individual onsite wastewater disposal systems appear to be adequate</p> <p>OR</p>
Priority 4	Residents ARE served by BOTH public water service and publicly owned wastewater facilities
Priority 5	This identified colonia does not have any occupied residents, i.e. there are no inhabitants

Table 3. Demographics of Colonias v. the State of Texas (Federal Reserve Bank of Dallas, 2015)

	Colonias	Texas
Age	27	33.6
Hispanic or Latino (%)	96	37.6
Citizen Rate, all ages (%)	73.1	89.1
Median Income (\$)	23,928	50,920
Poverty status (%)	42	17

Recent Efforts in Colonias

While the majority of colonia initiatives are state-led; some federal agencies provide funding or support development to communities. The United States Geological Survey (USGS) created a Colonia Health, Infrastructure and Platting Status (CHIPS) tool with GIS technology for use across organizations working with these communities. With this tool “the USGS provides detailed mapping and analysis facilities that enable investigation of a range of environmental health issues that stem from rapid population growth and urbanization in the border region” (May, 2010). This tool is an excellent example of providing transparent information that is accessible to all sectors of organizations working on colonia development. Another federal initiative is the State Community Development Block Grant Colonias Set-Aside administered through the Department of Housing and Urban Development. This program set aside funds in states with colonias to meet their needs with potable water, adequate sewer systems, or decent, safe and sanitary housing (HUD, 2014).

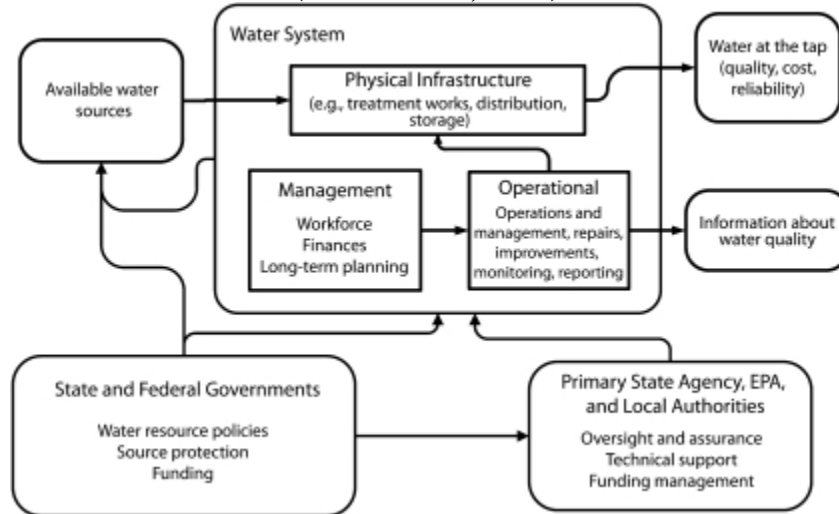
Non-profits like Proyecto Azteca and Communities Unlimited have also provided much needed support to colonias. The Environmental Protection Agency and United States Department of Agriculture—Rural Development started a joint grant initiative to address wastewater and potable water issues in colonias. One of the most extensive projects has been a partnership between the Rural Community Assistance Partnership (RCAP), Communities Unlimited, the Rural Community Assistance Corporation, and the Center for Advanced Spatial Technologies (CAST). Phase II of their project concluded in 2015 and Phase III is ongoing. Their findings provide the most recent descriptive information on colonias in all of the Border States.

Proyecto Azteca, one of the most successful non-profits working with colonias, implemented housing programs with a heavy community focus. In a newer development for colonia residents, Proyecto Azteca funded a LEED-certified home that will house thirty-two families using “top to bottom form of self-empowerment...to [address] the systemic problems faced by Colonias” (Lewis, 2015). Similarly, promotores/as (promoters) serve as a community health resource. Since the communities are underserved medically, community health centers “have been filling the vacuum left by private and public sectors”, and employ promotores(as) for outreach (Peña et al., 2010). The people-based approach of these centers is similar to programs in Latin America and provides a culturally familiar instigator of change. Scholars tend to agree that the next wave of colonia development should focus on “people-centered approaches...because they come from the conviction that the people themselves with proper support from public and private resources can succeed in designing policies and programs that meet their needs” (Arizmendi et al. 2010).

Wastewater Services and Colonias

The absence of wastewater services and lack of potable water are interrelated problems in colonias. Without wastewater services, there are high chances of human health and environmental pollutant risks to the area. In “Drinking Water Infrastructure and Environmental Disparities: Evidence and Methodological Considerations”, Dr. James VanDerslice looks at the connections between race, income and water infrastructure. In Figure 1, he explains the systems that work in order to provide communities with safe drinking water.

Figure 1. Framework of the Components of Drinking Water Infrastructure (VanDerslice, 2011)



According to the Safe Drinking Water Act, there are three divisions of water systems (42 U.S.C. § 300f). Community water systems “as defined by the Safe Drinking Water Act (SDWA), make up the first category of water systems. These systems serve at least 15 service connections or 25 or more full-time residents, and are subject to comprehensive regulatory requirements” (VanDerslice, 2011). As an example, this would be a municipal water provider. The second and third category, on the other hand, are not required to follow the regulations of the Safe Drinking Water Act. The second category includes “individual systems serving a single residence and shared systems serving multiple residents” and the third category “includes situations in which minimal infrastructure exists, characterized by the absence of piped water” (VanDerslice, 2011). Colonias that do not currently have wastewater infrastructure will likely fall under the second and third category, and lack regulation to ensure safe drinking water for residents.

VanDerslice specifically expands on categories two and three due to the lack of regulation. Colonias are able to develop inadequate systems because they traditionally are unregulated by building codes, which are usually the only regulation that private wells have (VanDerslice, 2011). Without oversight, even established waste water systems in colonias can be liabilities to the environment and public health. Wastewater that is “disposed of in outhouses, pit privies, and inadequate septic systems...seeps into the high water table, contaminating ground water” (Olmstead, 2004).

Largely, the lack of wastewater services comes down to the geographic location of the communities, and economic feasibility. Colonias lacking wastewater or potable water service are usually isolated and therefore, cost-prohibitive when utilities consider connecting them to the system. To fill the water gap, Texas has provisions for non-profits

or private corporations to provide service. Water organizations in Texas can range from “public- and investor-owned municipal systems, county systems, non-profit water supply corporations, for-profit private suppliers, more than a dozen types of public general law water districts and special law water districts” (Olmstead, 2004). Underserved or unserved colonias are more likely able to acquire service from non-profit water utilities, but funding can be difficult to secure. Another seemingly ideal option is annexation by the county. However, tax revenue from colonias is not enough to cover the infrastructure costs to expand existing public utility systems.

El Paso County has the majority of Priority One colonias, while Hidalgo County has the majority of Priority Two. There are 61 “Priority One” colonias, and 31 “Priority Two” colonias out of the 322 total in the county. The percentage of people under/unserved with drinking water is 6.34%, and people under/unserved with wastewater services is 27.51% (Rural Community Assistance Partnership, 2015). Reasons cited for the lack of service are the communities’ geographic isolation, groundwater quality and funding— common reasons for remaining colonias lack of infrastructure. The report outlined broad recommendations like “assistance with long-term capital planning” for small utilities, “coordination and support for interlocal agreements...to identify regional solutions that are cost-effective”, and training “to improve the technical, managerial and financial capacity of local leaders” (Rural Community Assistance Partnership, 2015).

While the Rural Community Assistance Partnership’s report examines colonias in detail across the border, there is still data missing— for example, specific health-related issues due to lack of drinking water and wastewater services. There has not been any

literature specifically on the health outcomes in the colonias falling under priority one or two, or red since the Office of Border Health released their *Survey of Health and Environmental Conditions in Texas Border Counties and Colonias* in 2007. This data is essential for accurately determining priority for funding.

Other Critical Issues

A major issue noted in various academic publications is the variety of definitions of a colonia. Depending on the function of the non-profit, government or NGO organization, the definition could be limiting, or non-inclusive of high need colonias. The varying definitions proves to be a roadblock to colonia development because “even though a community may be severely disadvantaged, it will not receive assistance unless it meets locational criteria. Alternatively, communities near the border (within 150 miles) may receive aid even though conditions may not be as severe” (Donelson et al, 2010). On the other hand, there is no protocol to remove a colonia designation—Rio Bravo, for example, is now its own municipality with a mayor and city council but still classifies as a colonia. The consensus that the lack of a clear definition of a colonia leads to misallocation of funds and disconnect between organizations.

Scholars also frequently note that depending on the agency, certain human-aspects of development get lost in the mix. For example, Dr. Cecilia Guisti “argues that economic development is often narrowly defined so that issues of safety and security, participation and engagement, and community identity and pride are overlooked” (Donelson et al., 2010). Where the state or federal government are unable to intervene, local government, community organizations and non-profits have opportunities to solve these issues. Also, “federal and state agencies have favored place-based solutions,

especially infrastructure upgrades (potable water, sanitation and paved streets and roads) while NGOs have pursue people-based strategies” (Peña et al., 2010). The place-based approaches have greatly improved colonias, but a different approach should be considered to bring colonias up to standards. In other aspects of colonia development like power and healthcare, community leadership has provided a successful model for sustainable change.

Finally, colonias are sometimes misunderstood as a product of immigration. However, case studies show that the majority of colonia residents are U.S. citizens. In reality, colonias are a “highly inadequate solution to a shortage of affordable housing in an impoverished area” (Henneberger et al., 2010). This perception could be detrimental to persuading elected officials to designate additional funding to support these communities.

Informal Wastewater System Case Studies

The United Nations General Assembly announced the human right to clean water and sanitation in 2010 through Resolution 64/292. Prior to that, in 2004 the Committee on Economic, Social and Cultural Rights adopted Comment No. 15, also relating the right to water. In their Manual on the Right to Water and Sanitation, they detail ways that decision-makers and those involved in water and sanitation can fulfill this basic human right. The book outlines the various hazards communities can face with inadequate wastewater services such as people “on low incomes spend[ing] a significantly greater proportion of their income on water” and disease “burdens those with low, or no, income with high health care costs and loss of ability to work” (United Nations, 2010).

Colonias suffer from similar issues that lead to the lack of wastewater services around the world. Residents are often not included in decision-making processes since they are almost exclusively low-income and living in isolated locations. (United Nations, 2010). A major difference between the examples discussed in the handbook and colonias is that the United States is a developed country that can provide the resources to support development. Low-cost solutions across the globe could be applicable to the most isolated colonias, which share similar characteristics and issues to global informal settlements.

International and Domestic Case Studies

There are a myriad of wastewater projects implemented in informal settlements consider as successes and failures. Most importantly, there are three primary hindrances to service according to a team from Uganda and the Netherlands (A.Y. Katukiza, 2012):

- 1) Poor accessibility for cesspool emptiers
- 2) Lack of legal status
- 3) Lack of interest for utilities to invest in an area due to high amount of renters

Colonias certainly fulfill the first two criteria due to the lack of transportation infrastructure and lack of paper trail for some properties, but the third only partially applies. The lack of interest for utilities investing in infrastructure to connect colonias is due to the low (or negative) profit margins associated with the low-income residents of the communities and the high price of connecting to remote areas as opposed to a renter occupancy rate.

Another universal concept related to wastewater collection is the need for it to be responsive to their users, be financially feasible and sustainable beyond external

interventions. Wastewater experts note that systems need to be “economically viable, social acceptable and technically and institutionally appropriate” (Rosemarin et al., 2008). They also implore professionals to consider options that “contribute to health improvement and environment protection. Population density, settlement patterns, landscape water availability, household income, ownership and socio-cultural issues are also key factors that cannot be ignored” (A.Y. Katukiza et al, 2012). In almost every case study, the success (or failure) of implementation falls on these factors.

Case studies in South Africa discuss the use of simplified sewerage, which mimics traditional systems but is “characterized by reduced pipe diameters, gradients and depth without compromising the design principles” (A.Y. Katukiza et al., 2014). Discussions of simplified sewerage appear in different studies, and can be found in Pakistan, Sri Lanka, Brazil, Columbia, Peru, Bolivia and South Africa (A.Y. Katukiza et al, 2012). This type of approach would allow the communities to connect to the traditional sanitation system, but reduce the cost to the community, utilities or other fund providers. In particular, Brazil’s success in implementing simplified sewerage in favelas was due to the element of “community participation...[which] resulted in reduced labour costs, [and] has also created a sense of ownership amongst the residents” (Ashipala et al., 2011). This solution has been most successful in high-density peri-urban areas and may not be applicable to colonias. Factors that lead to failure in other countries (South Africa) included the residents’ inability and unwillingness to pay for the operations and maintenance costs citing the national policy for “free basic water” as their reasoning (Ashipala et al, 2011).

Other options include biogas or composting toilets, both significantly different from simplified sewerage. The idea behind these types of systems are to use human waste for economic or community benefit. For example, biogas toilets provide biogas as an energy source from the anaerobic digestion from fecal matter (A.Y. Katukiza et al., 2013). These systems require technical experts and increased funding to establish, but the energy source product provides a return on investment for the community. Indian slums implemented this new technology, but its long-term efficacy has not been studied (A.Y. Katukiza, et al., 2012). Composting toilets follow a similar idea, but rather than providing an energy source, human waste becomes a fertilizer. These solutions have seen success abroad, but city officials state their preoccupations with some low-cost solutions. A city official in Cape Town “cautioned ‘it’s not equity, it’s getting a cheaper solution for poor people, so it’s almost like reinforcing the gap’” (Larsen, et al., 2012).

The United States also provides insight to potential sanitation system solutions. For example, the southern central region of Alabama also suffers from sub-par sanitation access. The population demographic is similar to colonias—“a low-income, rural population that does not have ready access to alternatives for domestic wastewater” (Izenberg et al, 2013). Homes in this region also use septic systems, some that may be in disrepair. Of note is the unsuitable soil conditions that cause an estimated 90% of on-site sanitation systems (OSS) to fail or function poorly (Izenberg et al, 2013). Without the knowledge or availability of alternatives, residents turn to a “straight pipe” (which dumps untreated waste into the environment) or cesspools (Izenberg et al., 2013). The study, published recently in 2013, does not detail a specific system implemented in the area, but provides insight on other regions of the United States that face similar issues.

Overall, wastewater managers and other implementing organizations have learned that the barriers that impede sanitation system implementation in informal communities are plentiful and reflect the same circumstances as colonias. The need for sustainable systems is imperative due to the need for communities to take ownership (financially and technically) of systems, have an equitable solution and clear and transparent communication between stakeholders (Pan et al., 2014). Policymakers, utilities, nonprofits and communities have much to learn from the successes and failures in other countries and across the United States.

Conclusions from Literature

Colonia infrastructure has improved since the Texas Legislature implemented the funding and framework for their development. However, there are still great strides to make in order to ensure that colonias residents have access to proper infrastructure to ensure basic rights to a healthy life. There is an extensive framework for government decision-makers, non-profits and utilities to work within to bring wastewater services to colonias; however, the lack of consistent communication between agencies and people-based solutions should be explored.

CHAPTER 3

RESEARCH PURPOSE AND DESIGN

The purpose of this study is to understand the current state of colonia wastewater services (or lack thereof) in Priority One colonias in El Paso County, Texas in order to recommend low-cost and sustainable wastewater solutions for the region. Through interviews with representatives from organizations that work closely with colonia development, an assessment of the current wastewater infrastructure and issues faced by colonias has been created. A set of wastewater system alternatives is explored in order to make recommendations for policy-makers, community organizers, utilities and other development organizations to consider when planning for these populations. These recommendations will provide just, environmentally and economically sustainable, and culturally-relevant suggestions when considering possibilities to service providers or advocates.

Research Questions

For the purpose of this paper, the following questions will be addressed:

- What is the current state of wastewater collection and treatment in Priority One colonias in El Paso County?
- What are barriers for utilities, nonprofits and policy-makers to establish services to these colonias?
- What systems or innovative technologies can be adapted from other sanitation projects in the United States and abroad?

These questions align with the major takeaways of the paper—the overview of El Paso County’s colonias lacking wastewater service, the alternatives analysis of

technologies, and recommendations for policy-makers, colonia advocates and service providers.

Methodology

In this report, I analyze colonias in El Paso County that lack access to clean water and wastewater services by interviewing experts on the county's specific situation. The focus of this report will be specifically on El Paso County because it has the highest number of Priority One colonias. There will be four main components of the paper—a literature review, analysis of current conditions, feasibility analysis on alternatives and recommendations.

The first part of this paper is a literature review and brief history of the emergence of colonias and the policies implemented to aid their development. Their history is essential to understanding the discrepancies between colonias that were able to develop adequate infrastructure. The federal, state and local policies establish the legal framework in which organizations work within to provide assistance. The literature review culminates with a review of case studies in the United States and international settlements that implemented alternative sanitation systems.

The second part of this paper assesses the current conditions and efforts in El Paso County. Semi-structured interviews were conducted with representatives from organizations that work closely with El Paso colonias produce an overview of the current wastewater situation in Priority One colonias. This overview outlines the current methods of wastewater disposal, efforts to establish service, challenges to current efforts and the consequences of existing infrastructure. There have been several organizations identified

that are key stakeholders in colonia development. Organizations represented in interviews are:

- United States Department of Agriculture- Rural Development (USDA-RD)
- Texas Department of Border Health
- Communities Unlimited
- Rural Community Assistance Partnership (RCAP)
- Texas Secretary of State
- El Paso County

Each of these organizations interacts with colonias in a different capacity, and interview questions reflect those differences. These interviews allow a well-rounded understanding of the current situation in El Paso County colonias to assess the feasibility of different potential wastewater systems for the community. Interview questions can be found in Appendix A, along with a list of interviewees and their organizations in Appendix B.

The final part of this report is an assessment of various low-cost (lower than connecting to municipal utilities) and sustainable wastewater technologies and recommendations for colonia development organizations and El Paso County to consider in future plans. Case studies from the literature review provide examples of potential technologies for implementation in informal communities around the world. These case studies provide valuable insight in the successes and failures of wastewater system implementation and will assist in analyzing their feasibility in El Paso County.

Wastewater systems that address issues faced in these colonias will be analyzed for their physical, economic and technical feasibility. Physically, the system should be compatible with the natural and built environment of colonias. Economically, the ideal solution is low-cost (initial and maintenance), sustainable and eligible to receive external funding. Technically, the system should be technologically feasible for implementation in

the county—the ideal system would be relatively low-tech and able to be serviced by the average colonia resident. These three larger sets of criteria will be used to suggest recommendations. Below is an outline of the various factors that are examined:

1. Compatibility with Physical Environment
 - a. Water table levels
 - b. Soil types
 - c. Availability of Land
2. Capital Requirements
 - a. Initial Costs
 - b. Maintenance Costs
3. Technical Requirements
 - a. Technical expertise required
 - b. Ability to meet permitting requirements
 - c. Energy or water demands
 - d. Hardware replacements
 - e. Lifetime of System
 - f.

The final component of this report is a recommended set of technologies for El Paso County government, service providers and colonia advocacy groups to consider when planning sanitation services. This section outlines justifies the use of dry composting toilets in El Paso County colonias.

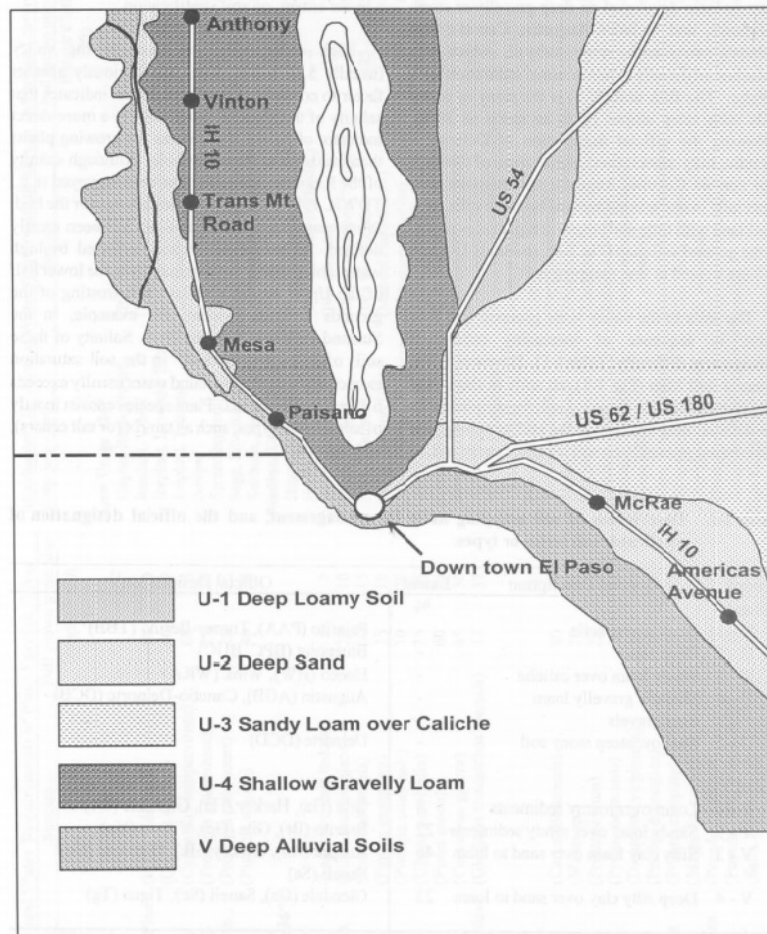
CHAPTER 4

EXISTING INFRASTRUCTURE AND CONDITIONS IN COLONIAS

Physical Environment of El Paso County

In El Paso County, the soil type may not be compatible to use leachfields for a natural secondary treatment of the effluent. Texas has five soil types (Ia, Ib, II, III, IV) with sandy soils as type I, and clay as type IV-- standard drainage fields cannot be used with type IV (Lesikar, 2015). In common terms, these soils range from fine, sandy loam subsoil, loamy and very fine sand to silty clay loam in the Rio Grande floodplain, shallow soils over caliche near the Franklin Mountains; and hard caliche or deep soils with silt loam subsoil on alluvial fans and foot of the Hueco Mountains (Graae, et al., 1998). Finally, there are steep rocky areas and shallow stony soils on the Hueco Mountains. In general, the soils “have a high content of lime, are alkaline, contain little organic matter and lose water rapidly due to evaporation” (USDA, 1971). Some soils in El Paso County are not suitable to naturally treat the effluent from septic tanks—for example, rocky soils will allow the effluent to drain into the groundwater too quickly or soils heavy in clay will not absorb well. Type IV and V soils would not be ideal for septic drainage.

Figure 2. Soil Map of El Paso County (Texas A&M University, 2000)



The Hueco Bolson aquifer is the main water source for El Paso County and the Ciudad Juarez area. The water levels declined significantly (several hundred feet) due to pumping for municipal needs until the late 1980s, but in present time, have stabilized (Texas Water Development Board, 2016).

El Paso County shares a similar climate to the rest of the Southwestern United States, arid with hot summers and cool winters. Precipitation is low with an annual average of 8.71 inches (NOAA, 2016), and the region also has low humidity. Evaporation in this area exceeds precipitation by a factor of ten (Graae, et al., 1998).

Capital and Funding Sources

Federal funding for colonias is provided by a variety of sources including the United States Department of Agriculture- Rural Development, Environmental Protection Agency, and Department of Housing and Urban Development. Typically these grants are utility-scale, and grantees are utility companies (often connecting colonias to a formal wastewater system).

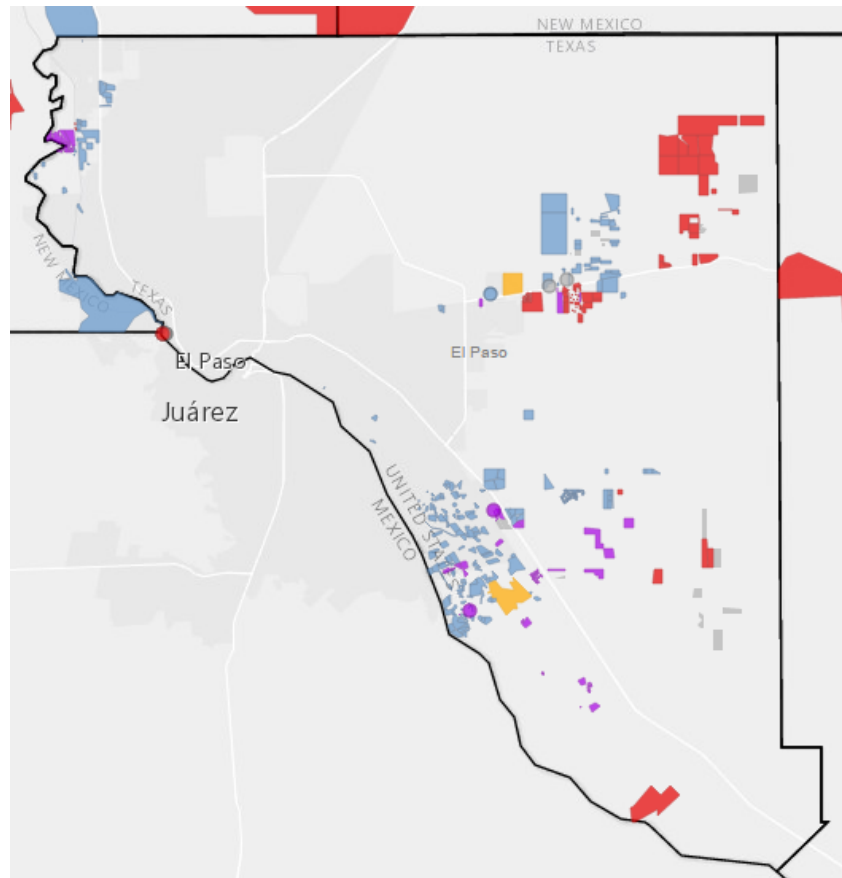
The state of Texas also provides funding opportunities for colonias through the Texas Department of Agriculture—these grants are for small scale, community projects, and are capped at \$.5 million (Munzer Alserraj, telephone interview with author, June 7, 2016). International organizations that fund colonias include the North American Development Bank through their Border Environment Infrastructure Fund (Erich Morales, telephone interview with author, July 20, 2016).

Current Wastewater Disposal Systems

The majority of colonias in El Paso County that are not connected to utility-served wastewater services use septic tanks (Munzer Alsarraj, Mark Pearson, Kathryn

Hariston, Erich Morales, phone interview by author, June 1, 7, 23 2016). Less frequently, colonias will use cesspools or outhouses (Erich Morales, phone interview by author, July 20, 2016). Colonias that are designated as Priority One have systems that are not in compliance with effluent standards, and present a health hazard to residents whereas priority two includes systems not in compliance without a health hazard (but could still be an environmental concern). The biggest threat that communities face with inadequate wastewater systems is contaminants from systems leaching into private wells causing a public health concern for residents, or raw sewage bubbling up into lawns where children play outside and people congregate. The stagnant puddles also can contribute to the presence of pests like mosquitoes and flies (Munzer Alsarraj, phone interview by author, June 7, 2016). Figure 3 shows the geographic location of colonias, categorized by their priority status. Priority One are shaded in red, Priority Two in purple, Priority Three in orange, Priority Four in blue, and Priority Five in light gray.

Figure 3. Map of Colonias in El Paso County (Rural Community Assistance Partnership, 2015)



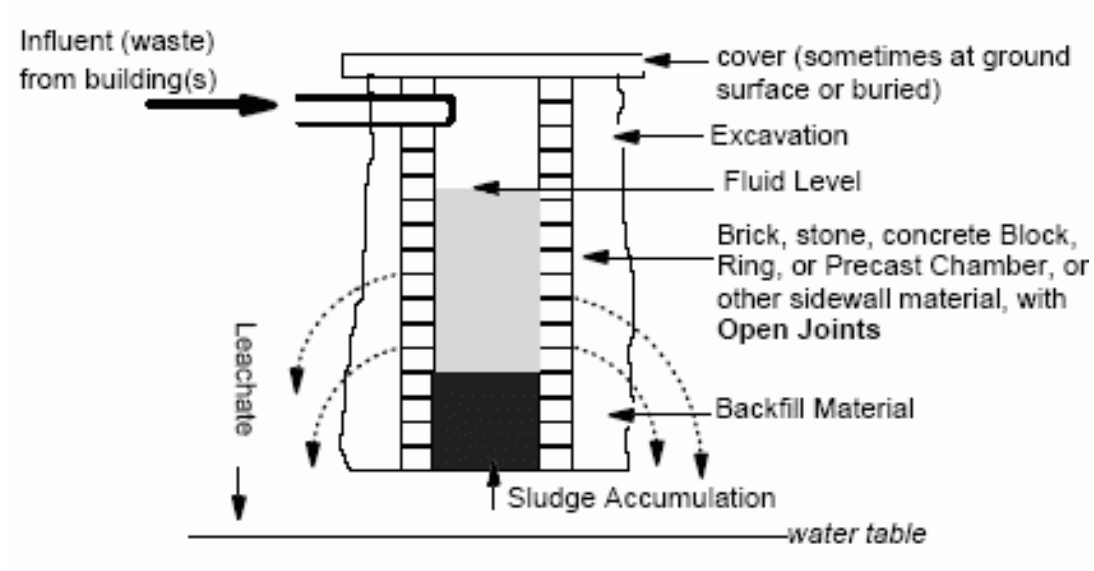
Cesspools

Cesspools are one of the methods that are used in colonias where sewage is stored until it is taken for processing at an off-site location. They are often used where “the ground is unsuitable for accepting discharged effluent and in places where no receiving watercourse is available” (Grant et al, 2008). When communities cannot be connected to utilities, and the above criteria are met, they are used because there is no other conventional solution. Cesspools are “in a specific class of waste management that are prohibited” (Erich Morales, phone interview with author, July 20, 2016).

Table 4. Pros and Cons of Cesspools (Grant et al., 2008)

Pros: <ul style="list-style-type: none">• The only conventional solution in some situations• On-site pollution is zero• DIY is possible• Nothing to go wrong (other than leaks and overflows)
Cons: <ul style="list-style-type: none">• Transport and final disposal have high ecological impact• Emptying is expensive and costs continue to increase• May not be permitted for new developments in some areas

Figure 4. Diagram of a Cesspool (Environmental Protection Agency, 2016)



Septic Tanks

Septic tanks are the most commonly found wastewater system solution found in colonias in El Paso County. They contain both an inlet and outlet, and typically contain a day's household sewage. The inlet allows the raw sewage to enter the tank, and allows the solids to settle to the bottom or float to the top. Liquids separate to the 'middle' of the 'crust' and 'sludge'. The new raw sewage pushes the separated effluent into the next chamber. Solid material needs to be removed from every six months, to every six years (depending on the system) by a sludge tanker (Grant et al, 2008). Septic tanks need to be followed by a secondary system or septic drain field, as they only serve as a primary treatment method. The United States Environmental Protection Agency implores that maintenance is the homeowner's responsibility (Environmental Protection Agency, 2002). Under the right circumstances, a septic tank should be able to service an individual household's waste; however, if there is a failure to maintain the tank, or the soil conditions are not compatible, it may back up or leak contaminated effluent.

Table 5. Pros and Cons of Septic Tanks (Grant et al, 2008)

Pros: <ul style="list-style-type: none">• Small probability of failure• Established technology• Low head loss• DIY is possible• Underground, so almost invisible• Prefabricated tanks can be installed in less than a day• Low cost compared with other forms of primary treatment
Cons: <ul style="list-style-type: none">• Often misunderstood• Provide primary treatment only; must not discharge directly to watercourse• Must be de-sludged regularly• Effluent is anaerobic and has odor (not a problem if effluent is contained)

Figure 5. Diagram of a Septic System

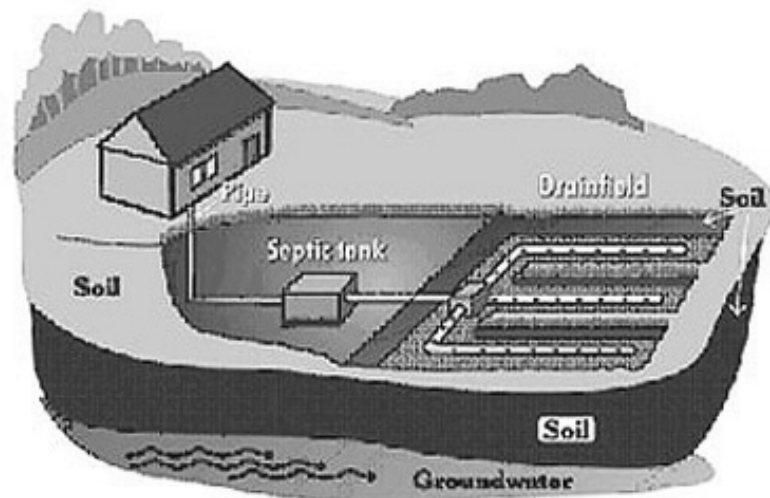


Diagram from U.S. Environmental Protection Agency

The Texas Secretary of State also recognizes that while septic systems can provide “adequate wastewater disposal, often pose problems because they are too small or improperly installed and can overflow” (Federal Reserve Bank of Dallas, 2006). Other inadequate infrastructure such as roads covered in caliche (a type of sedimentary rock) promote poor drainage, or the infrastructure for proper drainage is already poor. This causes water to collect during heavy rains and sewage to also pool. Septic systems installed in areas with “clay coils, shallow soils underlain by gravel and fractured limestone formations, seasonally high water tables, and caliche” (Texas A&M, 1998) may cause problems with the system.

However, when there are system failures, there is a myriad of reasons including: improper maintenance, outdated tanks, and incompatible soil types for septic. When tanks are not in compliance, representatives from Communities Unlimited and the Texas Secretary of State stressed that it is a case by case basis. Another reason for system failure is the accidental destruction of the leach field that allows the effluent to naturally filter back into the groundwater “in areas where they will be used as driveways” (Erich Morales, phone interview by author, July 20, 2016). Usually, properly functioning tanks where “soil is absorbent and natural biology [are] good at treatment as long as it is not located near a shallow well” (Mark Pearson, phone interview by author, June 1, 2016). Siting is an essential part of a properly function septic tank, thus, may be a viable option.

Outhouses

Although less common, there are also colonias that still use outhouses as their primary wastewater disposal system. Outhouses are structures around a toilet-- the human

waste goes past the toilet and collects into a pit, or into a bucket to be emptied by the owners. Similarly to septic tanks, outhouses may be an adequate solution if they are maintained correctly.

CHAPTER 5

TECHNOLOGIES FOR CONSIDERATION

The remainder of this paper will analyze various technologies that can be implemented in colonias in El Paso County that are not currently serviced by formal wastewater utilities. The chosen wastewater systems are stabilization ponds, dry composting toilets and constructed wetlands. The technologies chosen are based on an initial review suggesting comparability with the landscape and available resources in El Paso County.

Stabilization Ponds

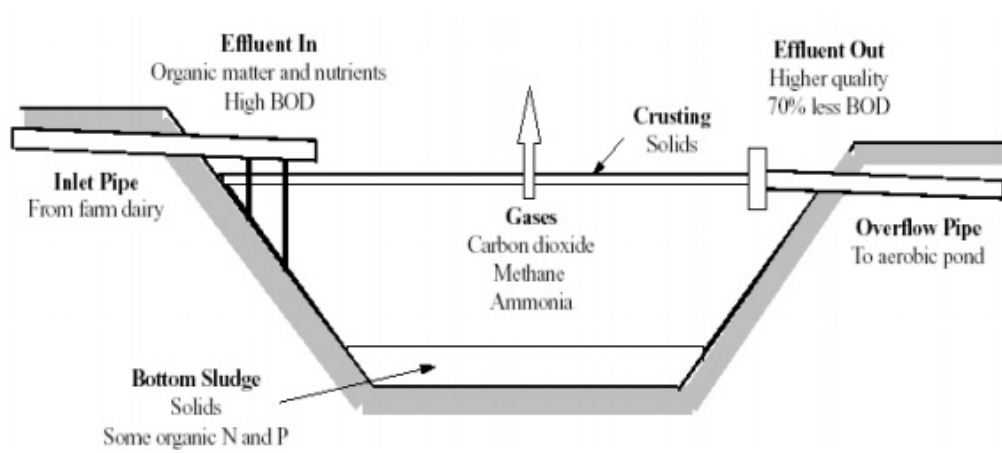
Stabilization ponds are also known as settlement ponds, lagoons, or sewage ponds and have been used in the United States and Europe. These ponds use oxygen, sunlight, and algae to treat the wastewater. The treatment takes place over a series of ponds, thus requiring 10-20m² per person.

There are various types of stabilization ponds, including: aerobic ponds, shallow ponds, aerated ponds, aerobic-anaerobic ponds, maturation ponds, anaerobic ponds, controlled discharge ponds, and complete retention ponds. For the purpose of this paper, only anaerobic ponds will be considered.

Table 6. Pros and Cons of Stabilization Ponds (Grant et al, 2008)

<p>Pros:</p> <ul style="list-style-type: none">• Can provide primary, secondary, and tertiary treatment• Resistant to temporary organ and hydraulic overload• Can be beautiful• Pathogen removal can be excellent• Sludge removal is very infrequent• May not need liner if clay is present• DIY is possible• Wind-powered aeration devices possible• Excellent wildlife habitat
<p>Cons:</p> <ul style="list-style-type: none">• Require large area (approximately 10-20m²/person)• Occasional odors can be a problem if early stages are not aerated• Requires power if aerated• Energy consumption, if aerated, is typically far higher than for an equivalent package plant• Effluent may contain high levels of algae• Sludge removal may be difficult• Expensive for smaller systems• Needs special health and safety considerations• Plastic linkers can be vulnerable

Figure 6. Diagram of an Anaerobic Stabilization Pond (Ramadan and Ponce, 2003)



Compatibility with Physical Environment

Stabilization ponds require a significant plot of land—either the individual homeowner would be responsible for purchasing additional land, or it can be established at a community level and support multiple households in a colonia. According to the World Bank, stabilizations ponds require about 3-5m² per person (World Bank Group, 2016). The land requirements for the stabilization ponds would likely require acquiring land at a community level—it is spatially consuming to build a pond on every household parcel, if the lot is able to accommodate such a size.

Ponds are also meant to be sited away from households and areas where people are because of the odors they give off if they are not aerated. They are also rather deep—“typically more than eight feet deep” (Environmental Protection Agency, 2011). The BOD removal in effluent reaches around 60%, but still cannot be discharged because the BOD levels remain too high (Environmental Protection Agency, 2011). Thus, a secondary treatment system would be required to cleanse water to effluent standards.

Capital Requirements

The initial costs of stabilization ponds are variable, largely depending on the cost of land in the area and labor. Construction and maintenance costs are relatively low--approximately \$59 every five years for desludging the bottom of the pond. (Wastewater Solutions, 2016). Creating smaller scale ponds is more expensive, since stabilization ponds can be undertaken by communities due to economies of scale.

Technical Requirements

The technical expertise beyond constructing the initial pond is minimal— other than “sampling, analysis, and general upkeep, the system is virtually maintenance-free”

(Environmental Protection Agency, 2011). Also, the sludge depth should be measuring annually. As previously stated, the ponds must be desludged every five to ten years—their lifetime should be sustained as long as the pond is properly maintained.

Anaerobic stabilization ponds are not specifically banned from the wastewater permitting in El Paso County. They also do not require any energy input in their maintenance processes.

Table 7. Treatment Efficiency of Stabilization Ponds (Graae et al., 1998)

Pollutants	Removal Efficiency	Influent Concentration	Effluent Concentration	Effluent Standards
BOD₅	80%	221 mg/L	44 mg/L	20 mg/L
TSS	N/A	130 mg/L	100mg/L	20 mg/L
Nitrogen	90%	32.5 mg/L	.3 mg/L	5 mg/L
Total Coliform	N/A	N/A	10,000 mg/L	<400 mg/L

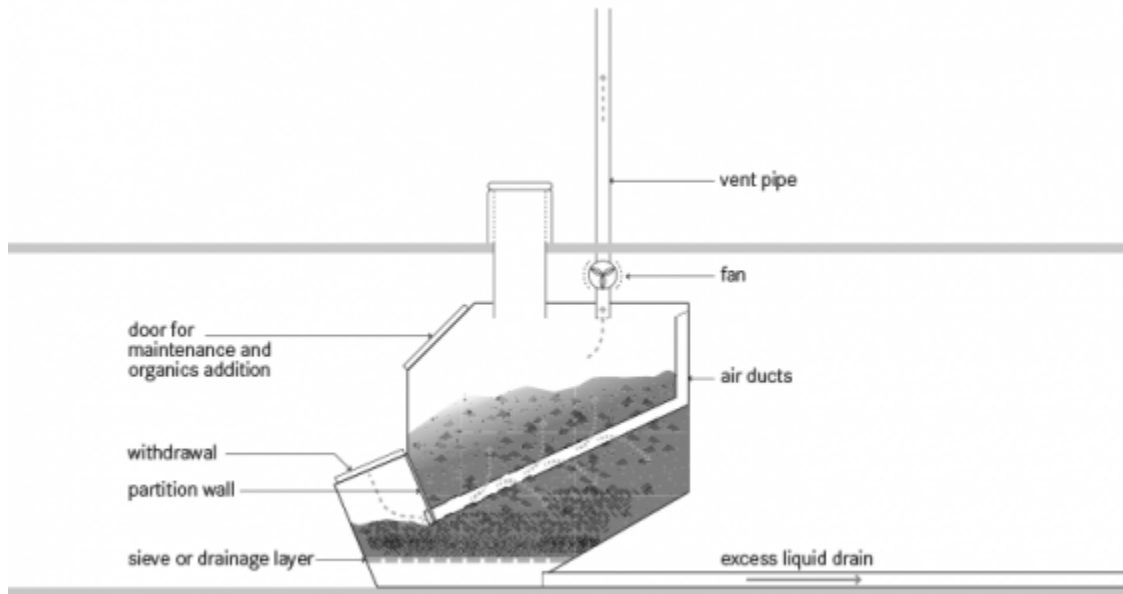
Dry Composting Toilets

Composting toilets are considered 'dry' because they produce little to no effluent. The toilets look like regular toilets, but the human waste goes down a chute into a storage tank. This system uses aerobic decomposition and composting to treat the wastewater, and produces a manure byproduct. Both solid and liquid waste are deposited into the same chamber, and eventually the liquid is drained from the bottom for treatment or disposal. (Grant et al. 2008) The human waste is composted and can be used as an agricultural fertilizer with a properly functioning system but can be difficult to achieve.

Table 8. Pros and Cons of Dry Composting Toilets (Spuhler, 2016)

Pros: <ul style="list-style-type: none">• Proper conditions allow for thermophilic composting, which turns human waste into humus (compost)• Can be constructed virtually anywhere• Can create simple composting toilets with locally sourced material• No water required and no risk of soil water pollution• Produces humanure
Cons: <ul style="list-style-type: none">• Depends on local climate, cold temperatures may hamper composting process• Operation and maintenance are required for safe composting process• Require use of “organic bulking material” to control moisture and temperature• Requires large amount of organic bulking material and thermophilic composting is not always achieved

Figure 7. Diagram of a Dry Composting Toilet (Spuhler, 2016)



Compatibility with Physical Environment

Dry composting toilets do not require a specific soil type because they do not produce any effluent run-off. They work best in environments where the fecal matter can dry easily to reduce the amount of harmful bacteria and produce “humanure”. Given the rapid evaporation and limited amount of rainfall in El Paso County would be a favorable climate for this type of system. A study in Ciudad Juarez, Chihuahua, Mexico demonstrated that a type of composting toilet (Sistema Integral de Reciclamiento de Desechos Organicos [SIDROS]) produced “high grade” compost in only 35.8% of SIDROs after 6 months (Redlinger et al., 2001).

Capital Requirements

Depending on the sophistication of the technology—composting toilets can be a DIY initiative and costs will be significantly lower, however the cost of a pre-fabricated system for a household with two adults and two children “could range anywhere from \$1,200 and \$6,000 depending on the system” (Environmental Protection Agency, 1999). There are examples of community composting toilets, but these “large-capacity systems for public facility use can cost as much as \$20,000 or more” (Environmental Protection Agency, 1999). Another option that is built on-site “such as cinder-block, double-bault system are as expensive as their materials and construction labor costs” (Environmental Protection Agency, 1999), and can be a cost-effective solution if allowed by municipalities.

Technical Requirements

Instead of disposing wastes as effluent, human waste is reused as a resource (humanure). Most composting toilets are built entirely above ground (World Bank Group, 2016). These systems must be constructed correctly to ensure that the compost product is safe for human use. The operation and maintenance requirements for composting toilet systems does not require specially trained labor, but does need routine maintenance to ensure proper functions (Environmental Protection Agency, 1999).

The greatest challenge facing composting toilets is policy that may prevent their construction. The City of El Paso allows the construction of dry composting toilets as long as they are “listed with the NSF...[which] indicates its ability to meet the requirements of NSF Standard Number 41 testing and certification requirements” (El Paso, Texas, Municipal Code § 18.20.300). There is also a larger scale composting toilet in El Paso, TX in Tom Mays Park in the Franklin Mountains—this could serve as an example for implementation on the community level in colonias with similar terrain (Victoria Advocate, 2006).

Constructed Wetlands

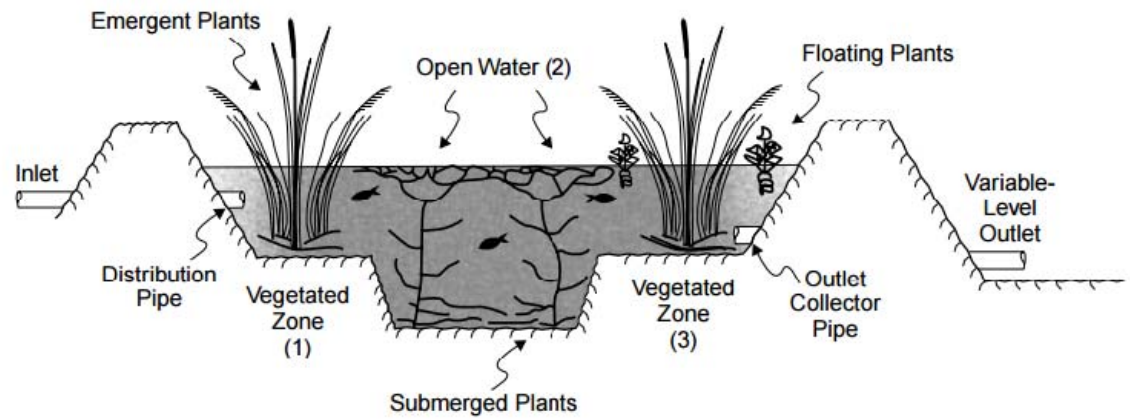
Artificially constructed wetlands can be used to further purify wastewater effluent. These wetlands use the natural process of water filtration to remove suspended solids along vegetation. Microorganisms live on these plants, and remove the pollutants from water. In fact, the Environmental Protection Agency notes that wetlands can be used to remove “nutrients, such as nitrogen and phosphorus...from areas where fertilizers or manure have been applied and from leaking septic fields” (Environmental Protection Agency, 1999).

Wetlands need to be constructed uplands and outside floodplains or floodways to prevent damaging the natural wetland system (Environmental Protection Agency, 1999). Then, the ground is engineered by excavating, backfilling, grading, diking, and installing water control structures to establish the necessary hydraulic flow (Environmental Protection Agency, 1999). The Environmental Protection Agency recommends constructed wetlands for small communities because it is “affordable, operable, and reliable” and appropriate for “areas where inexpensive land is generally available and skilled labor is less available” (Environmental Protection Agency, 1999).

Table 9. Pros and Cons of Constructed Wetlands (Grant et. al, 2008)

Pros: <ul style="list-style-type: none">• Can be aesthetically pleasing• Low technical expertise needed for maintenance• Lower cost than traditional wastewater systems• Can achieve good BOD/COD reduction and remove pathogens• Tolerant to fluctuations in hydraulic and contaminant load
Cons: <ul style="list-style-type: none">• Odor and mosquito production• Large land requirement• Greater management requirements• Can take up to two years to achieve optimum treatment efficacy

Figure 8. Diagram of a Constructed Wetland (Environmental Protection Agency, 1999)



Compatibility with Physical Environment

Constructed wetlands may be constructed in any soil type and close to the water table because the underneath should be impermeable to ensure untreated effluent does not percolate into the groundwater.

Constructed wetlands require a large amount of land to function properly (3-5m²/person), so similarly to stabilization ponds, they require an individual to purchase more land, or for a community-led effort to secure ample land.

Capital Requirements

The principal costs of constructed wetlands are the construction material and labor costs, and the cost of purchasing land to place the system on. It is difficult to determine a cost range due to the variability in construction and property costs.

Technical Requirements

Depending on the type of constructed wetlands, there are different technical requirements. However, in every system, the wastewater must be “pre-treated to remove gross solids” (World Bank Group, 2016) and allow the liquid to flow across the wetlands. Also, the bed of the wetland should be sealed to avoid percolation of wastewater into the ground. When the system is a horizontal flow bed, it is “built using a gravel medium, into which the reeds are planted” (World Bank Group, 2016). Wetlands typically need 3-5 m² per person if it is meant to treat raw sewage—however it can be used as a secondary system to improve the quality of effluent from septic tanks.

Table 10. Wastewater Treatment Efficiency for Constructed Wetlands (Graae et al., 1998)

Pollutants	Free Water Surface Wetlands	Subsurface Flow Wetlands
BOD₅	5-10 mg/L	5-40mg/L
TSS	5/15mg/L	5-20mg/L
Total Nitrogen	5-10mg/L	5-10mg/L

Package plants

Package plants are larger-scale septic systems that are used for single-household waste management. These plants can be purchased “off the shelf” for installation at home. There are various types of package plants but the most common types use biological aeration to process wastewater (Environmental Protection Agency, 2000). These plants typically use electricity to function.

Table 11. Pros and Cons of Package Plants

Pros: <ul style="list-style-type: none">• Compact• Fast installation• Readily available• Models with certification and approval available• Medium cost (comparatively) for secondary treatment• Maintenance contract often available from installer• Can be unobtrusive as mostly buried underground
Cons: <ul style="list-style-type: none">• Uses electricity (amount varies considerably between models)• Requires regular maintenance, including costly replacement of parts for proper function• Not DIY• Slight noise and odor of some models may cause annoyance• Not generally tolerant of fluctuating or intermittent loads• Small size limits buffering effect• No treatment in event of power cut or mechanical failure• Large amount of secondary solids may be created (design dependent)

Compatibility with Physical Environment

Package plants are often used in areas like trailer parks, highway rest stops and rural areas (Environmental Protection Agency, 2000), they are solutions for small communities with a small amount of wastewater discharge. They are compatible with any type of soil type, and when working properly, should discharge adequately cleansed effluent. Their land requirement is around half an acre, and some colonia lots may not be able to support the space (Harold Hunter, telephone interview with author, June 2, 2016).

Capital Requirements

The capital requirements for package plants are quite high since they are pre-fabricated systems that are purchased ‘off-the-shelf’. Aerated systems may cost from around \$7,000-\$10,000, and have a land requirement (Harold Hunter, telephone interview with author, June 2, 2016). For example, an extended aeration plant costs around \$4-\$6 per gallon of water treated and \$350 a year for maintenance. The initial costs vary from manufacturer, and typically maintenance will be included in contracted price.

Technical Requirements

Package plants are easy to install, and require little maintenance. However, if they break, the cost fixing the system would be costly. The maintenance process for extended aeration plants are “labor-intensive and require semi-skilled personnel, and are usually completed through routine contract services” (Environmental Protection Agency, 2000). The typical maintenance requirements are checking motors, gears, blowers and pumps. Extended aeration systems require energy to run—this would prove to be difficult to implement if colonias do not have a consistent source of power.

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

There has been significant progress in connecting many colonias to formal wastewater utilities, but there are still populations that lack access. Interviews stressed the case by case basis of the remaining colonias in El Paso when considering different wastewater, thus two systems will be recommended for consideration. The amount of colonias and populations reduced significantly from 1988 where there were 350 colonias with a population of 53,000 lacking wastewater facilities. Today, Communities Unlimited reports that 92 communities fall under their priority one and two classifications—the total population are 8,667 and 8,025, respectively (Rural Community Assistance Partnership, 2015). The colonias that do not have access to wastewater utilities are due to the technical costliness and lack of feasibility to do so (Mark Pearson, Harold Hunter, telephone interview with author, June 1 & 2, 2016). Wastewater utilities, whenever financially and technically possible, connect colonias. The review of case studies of other worldwide locations lacking wastewater services often turned to alternative on-site sewage systems.

Recommendations

Given the nature of the remaining colonias not serviced by wastewater providers, I recommend that dry composting toilets be considered as a potential solution until they are connected to service, or as a long-term solution. While El Paso County has been proactive in providing service to colonias, the remaining 350 are not financially or technically feasible to do so at this time. When considering capital requirements, composting toilets can be constructed do-it-yourself, or pre-fabricated systems. They also

have the flexibility to service entire communities or individual households—a DIY system could provide an opportunity for residents to be involved in construction firsthand to become familiar with the system.

Also, constructed wetlands as a secondary treatment system should be considered in areas where septic tank effluent quality is questionable. Currently, the State of Texas does not allow constructed wetlands to be used as primary treatment (Texas Code §§217.201), but it can provide a more obvious secondary treatment for effluent (as opposed to septic drainfields). Constructed wetlands would provide an amenity for the home, and natural beauty for the community.

A community approach could be explored, but ownership of the communal wastewater system has been an issue in the past (Erich Morales, telephone interview with author, July 19, 2016). Communities with strong organization may benefit from this type of system, but accountability is key to sustaining a working system. The organization or group leading the system needs the ability to collect fees and organize accounting.

Further Research

The work completed by Communities Unlimited and the Rural Community Assistance Partnership is invaluable to the study and development of colonias. In order to further explore the possibilities of wastewater system infrastructure, colonias residents should provide input on their specific needs for their community. As stated in the interviews, each community falls under different circumstances, and residents' knowledge is invaluable in assessing a relevant and successful alternative solution.

Also, this research did not explore the possibility of rehabilitation of the existing septic systems. This should be explored to leverage the existing infrastructure and

perhaps save on costs on implementing new infrastructure. The cost of removing the septic systems should also be considered when considering an alternative technology for these communities.

APPENDIX A

COLONIAS INTERVIEW GUIDE

Introduction: Thank you for taking the time to speak to me. The purpose of this research is to better understand the current waste water infrastructure in colonias that are not connected to utilities. The final product will be an alternatives analysis of different sustainable and low-cost waste water systems that could be implemented in communities where it is not technically or financially feasible to connect to utilities.

I. **Industry/institutional Infrastructure**

- a. In what capacity does [organization name] interact with colonias?
- b. What relationship does [organization name] have with [government agencies, non-profits, utilities]*
- c. What funding sources (loans, grants, etc.) are available to [organization name] to support colonias?
 - i. What types of projects can these funds be used for?
 - ii. Are they distributed at a family or community level?

*Variable depending on type of organization. Ex. If government agency, will ask about relationship with non-profits and utilities. If non-profit, will ask about relationship with government agencies and utilities

II. **Existing infrastructure questions**

- a. There are colonias that are not connected to formal wastewater utilities. What methods of wastewater disposal do these communities use?
- b. Are [method of wastewater disposal] typically in compliance with effluent standards?
 - i. If not, what actions are taken?
 - ii. Have there been any health concerns with [method of wastewater disposal]?
- c. If we wanted to implement a communal system, is there physical space to do so?

III. **Outcomes of Prior Interventions & Looking Forward**

- a. Have there been prior efforts to bring wastewater service to colonias?
- b. What were the outcomes of [program name]?
- c. Given the current state, what would your suggestions be to provide service to these colonias?

APPENDIX B

LIST OF INTERVIEWEES AND AFFILIATIONS

Munzer Alsarraj, Infrastructure Program Manager, El Paso County

Harold Hunter, Texas State Coordinator, Communities Unlimited

Erich Morales, Assistant County Attorney, El Paso County Attorney*

Mark Pearson, Development Management Specialist, Communities Unlimited

*The quotations and cited material reflect the opinions and views of the interviewee and are not representative of the El Paso County Attorney Office

REFERENCES

- Arizmendi, Lydia, David Arizmendi, and Angela Donelson. "Colonia Housing and Community Development", edited by Angela J. Donelson and Adrian C. Esparza, 87-100. Tuscon: The University of Arizona.
- Ashipala, N., and N. P. Armitage. "Impediments to the adoption of alternative sewerage in South African urban informal settlements." *Water Science & Technology* 64, no. 9 (2011).
- Barton, Jordana, Emily Ryder Perlmeter, Elizabeth Sobel Blum and. Raquel R. Marquez . *Las Colonias in the 21st Century*. Dallas: Federal Reserve Bank of Dallas, 2015. Accessed January 15, 2016.
<https://www.dallasfed.org/assets/documents/cd/pubs/lascalonias.pdf>.
- Cavanagh, Sheila M. *Thirsty colonias: Determinants of water service coverage in South Texas*. Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University, 2001.
- City of El Paso. "Plan El Paso: City of El Paso, Texas Comprehensive Plan" El Paso, TX: City of El Paso, 2012.
- "El Paso shines in Franklin Mountains." *Victoria Advocate*, October 26, 2006.
- Esparza, Adrian X., and Angela Joy Donelson. "The colonias reader: economy, housing, and public health in US-Mexico." (2010).
- Federal Reserve Bank of Dallas. "Texas Colonias: a Thumbnail Sketch of the Conditions, Issues, Challenges and Opportunities." Dallas: Federal Reserve Bank of Dallas, 2006.
- Graae, Joshua, Shannon Keithley, Mimi Luc, Justin Pawl, and Daniel Wilson. "Alternative Solutions for Wastewater Treatment in U.S.-Mexico Border Colonias: an Analysis from Socio-Economic and Technological Perspectives." Master's Thesis, Santa Barbara, CA, 1998.
- Grant, Nick, Mark Moodie and Chris Weedon. *Sewage Solutions: Answering the Call of Nature*. Gabriola Island: New Society Publishers, 2008.

Henneberger, John, Kristin Carlisle, and Karen Paup. "Housing in Texas Colonias." In *The Colonias Reader*, edited by Angela J. Donelson and Adrian C. Esparza, 101-114. Tuscon: The University of Arizona Press, 2010.

Introduction to *The Colonias Reader*, Edited by Angela J Donelson and Adrian C. Esparza. Tuscon: The University of Arizona Press, 2010.

Izenberg, Maxwell, Olivia Johns-Yost, Pauline D. Johnson, and Joe Brown. "Nocturnal Convenience 1: The Problem of Securing Universal Sanitation Access in Alabama's Black Belt." *Environmental Justice* 6, no. 6 (2013): 200-205.

Katukiza, A. Y., M. Ronteltap, C. B. Niwagaba, J. W. A. Foppen, F. P. N. L. Kansiime, and P. N. L. Lens. "Sustainable sanitation technology options for urban slums." *Biotechnology advances* 30, no. 5 (2012): 964-978.

Khalfan, Ashfaq, et al. *Manual on the Right to Water and Sanitation*. Geneva, Centre on Housing Rights and Evictions, 2007. Accessed January 15, 2016.

Larsen, Tove A., G. Gebauer, Harald Gründl, Rahel Kuenzle, C. Lethi, Ulrike Messmer, Eberhard Morgenroth, and Bernhard Ranner. "Diversion for safe sanitation: A new approach to sanitation in informal settlements." In *Proceedings of the Second International Faecal Sludge Management Conference*, Durban, South Africa, vol. 2931, p. 18. 2012.

Lesikar, Bruce. "On-site wastewater treatment systems: septic tank/soil absorption field." College Station, TX: Texas A&M., 2015.
<http://theurbanrancher.tamu.edu/construction/septictank.pdf>

Lewis, Caitlin. "Texas Colonias: Injustice by Definition." *Environmental and Earth Law Journal* (EELJ) 5, no. 1 (2015): 1.

May, Marlynn. "Living Betwixt and Between: Health in Borderland Colonias." In *The Colonias Reader*, edited by Angela J. Donelson and Adrian X. Esparza, 163-175. Tucson: The University of Arizona Press, 2010.

National Oceanic and Atmospheric Administration. "Monthly Precipitation Totals: El Paso, TX." National Weather Service Weather Forecast Office. Accessed June 10, 2016. http://www.srh.noaa.gov/epz/?n=elpaso_monthly_precip.

- Olmstead, Sheila M. "Thirsty colonias: Rate regulation and the provision of water service." *Land Economics* 80, no. 1 (2004): 136-150.
- Pan, S. M., N. P. Armitage, and M. B. Van Ryneveld. "Sustainable and equitable sanitation in informal settlements of Cape Town: a common vision?" *Water SA* 41, no. 2 (2015): 222- 231.
- Parcher, Jean W., and Delbert G. Humberson. CHIPS: a new way to monitor colonias along the United States-Mexico border. No. 2007-1230. Geological Survey (US), 2007.
- Peña, Sergio, E. Lee Rosenthal. "Colonias Health Issues in Texas." In *The Colonias Reader*, edited by Angela J. Donelson and Adrian C. Esparza, 176-189. Tuscon: The University of Arizona Press, 2010.
- "Ponds and Wetlands." *World Bank Group*. Accessed July 10, 2016.
<http://water.worldbank.org/shw-resource-guide/infrastructure/menu-technical-options/ponds-and-wetlands>.
- Ramadan, Hamzeh, and Victor M. Ponce. "Design and Performance of Waste Stabilization Ponds." Accessed August 2, 2016.
<http://stabilizationponds.sdsu.edu/>.
- Rao, Kate. "Cesspools in Hawaii," *US Environmental Protection Agency*. Last modified May 23, 2016. <https://www.epa.gov/uic/cesspools-hawaii>.
- Redlinger, Thomas, Jay Graham, Veronia Corella-Barud, and Raquel Avitia. "Survival of Fecal Coliforms in Dry-Composting Toilets." *Applied and Environmental Microbiology* 67, no. 9 (2001): 4036-4040.
- Rivera, Danielle Zoe. "The Forgotten Americans: A Visual Exploration of Lower Rio Grande Valley Colonias." *Michigan Journal of Sustainability* 2 (2014).
- Rural Community Assistance Partnership. "Phase II Colonia Map." *Rural Community Assistance Partnership*. Accessed August 2, 2016.
<http://crginc.maps.arcgis.com/apps/webappviewer/index.html?id=1d3a4eefcaee45519603e4aac90a223e>.

- Rural Community Assistance Partnership. U.S.-MEXICO BORDER NEEDS ASSESSMENT AND SUPPORT PROJECT: PHASE II ASSESSMENT REPORT. Washington, D.C. Rural Community Assistance Partnership, 2015. Accessed January 15, 2016.
- Spuhler, Dorothee. "Composting Chamber," Sustainable Sanitation and Water Management, Last modified May 19, 2016. <http://www.sswm.info/print/1743?tid=819>.
- Texas A&M University, Agricultural Research Center at El Paso. "Soil Resources of El Paso: Characteristics, Distribution, and Management Guidelines." El Paso, TX: Texas A&M, 2000. <http://elpaso.tamu.edu/files/2011/10/Soil-Resources-of-El-Paso.pdf>
- Texas A&M University, Texas Water Resources Institute. "How Safe are Septic Tanks?" College Station, TX: Texas A&M, 1998.
- Texas Water Development Board. "Summary." *Hueco-Mesilla Bolson Aquifer*. Accessed June 10, 2016. <http://www.twdb.texas.gov/groundwater/aquifer/majors/hueco-mesilla-bolsos.asp>.
- U.S. Department of Agriculture, Soil Conservation Service. "Soil Survey: El Paso County, Texas." Government report, Washington D.C., 1971. http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/texas/TX624/0/EI%20Paso.pdf/.
- U.S. Environmental Protection Agency. "Constructed Wetlands Treatment of Municipal Wastewaters." Cincinnati, OH: EPA, 1999.
- U.S. Environmental Protection Agency. "A Homeowner's Guide to Septic Systems." Washington D.C.: EPA, 2002.
- U.S. Environmental Protection Agency. Office of Water. *Water Efficiency Technology Fact Sheet: Composting Toilets*. EPA 832-F-99-066. Washington D.C.: U.S. United States Government Printing Office, 1999.
- U.S. Environmental Protection Agency. Office of Water. *Water Efficiency Technology Fact Sheet: Package Plants*. EPA-832-F-00-016. Washington D.C.: U.S. United States Government Printing Office, 2000.

U.S. Environmental Protection Agency. Office of Research and Development. *Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers*. By Richard H. Bowman, E. Joe Middlebrooks, and Laurel J. Staley. EPA/600/R-11/088. Cincinnati, OH: U.S. United States Government Printing Office, 2011.

U.S. Department of Housing and Urban Development. "State Community Development Block Grant Colonias Set-Aside" 2014. Accessed January 15, 2015.
<https://www.hudexchange.info/programs/cdbg-colonias/>.

VanDerslice, James. "Drinking water infrastructure and environmental disparities: evidence and methodological considerations." *American Journal of Public Health*. 101, no. S1 (2011): S109-S114.

Wastewater Innovations. "Technology: Waste Stabilization Ponds." *Wastewater Innovation: Making Sanitation a Sustainable Business*. Accessed June 10, 2016.
<http://wastewaterinfo.asia/sites/default/files/tech-sheets/waste-stabilization-ponds.pdf>.